National Nuclear Security Administration
Defense Nuclear Nonproliferation

Reduced Enrichment for Research and Test Reactors (RERTR)

Parrish Staples
U.S. Department of Energy
National Nuclear Security Administration
Office of Global Nuclear Material Threat Reduction (NA-212)

April, 11-13, 2005
RRFM
Budapest, Hungary

Argonne National Laboratory
Operated by the University of Chicago

INL
Idaho National Laboratory

Program Staff and Laboratory Functions

National Nuclear Security Administration
Defense Nuclear Nonproliferation

Argonne National Laboratory

Bakel, A
Birtcher, R
Finlay, M
Garner, P
Guelis, A
Hanan, N
Hofman, G
Holland, J
Kim, Y
Leyva, A
Liaw, J
Matos, J
Mo, S
Olson, A
Quigley, K
Rest, J
Roglans-Ribas, J
Snelgrove, J
Stillman, J.
Travelli, A
Turski, R
Vandegrift, G
Wiencek T

- **Technical Integration**
- **Conversion Analysis**
- **^{99}Mo Conversion**
- **Fuel Development**

Idaho National Laboratory

Ambrosek, R
Briggs, R
Chang, G
Clark, C
Cowan, D
Halinan, N
Janney, D
Jue, J-F
Keiser, D
Knighton, G
Meyer, D
Meyer, M
Moore, K
Nash, J
Taylor, S.
Tomberlin, T
Wachs, D
Ward, M.
Wight, J

- **Fuel Development**
- **Fuel Procurement**

Idaho National Laboratory

Program Objective

National Nuclear Security Administration
Defense Nuclear Nonproliferation

The RERTR program mission supports the minimization and, to the extent possible, elimination of the use of HEU in civil nuclear applications by working to convert research reactors and radioisotope production processes to the use of LEU fuel and targets throughout the world.

Specific projects include:

- Developing advanced, high-density LEU fuels
- Providing assistance to research reactors for feasibility studies, conversion analyses, and licensing support
- Converting research reactors to the use of LEU fuel
- Developing and demonstrating LEU-based ^{99}Mo production techniques
- Working with reactor operators to ensure that new reactors are designed to use LEU fuels

Coordination with the Fuel Repatriation Programs

- FRR SNF Acceptance Program
- RRRFR Program

ARGONNE NATIONAL LABORATORY
OPERATED BY THE UNIVERSITY OF CHICAGO

INL
Idaho National Laboratory

RERTR Implementation

National Nuclear Security Administration
Defense Nuclear Nonproliferation

1) **Work to ensure that an LEU fuel alternative is provided that maintains a similar service lifetime for the fuel assembly**
2) **Ensure that the ability of the reactor to perform its scientific mission is not significantly diminished**
3) **Ensure that conversion to a suitable fuel can be achieved without requiring major changes in reactor structures or equipment**
4) **Demonstrate that the conversion and subsequent operation can be accomplished safely and LEU fuel meets safety requirements**
5) **Determine, as possible, that the overall costs associated for conversion to LEU fuel does not increase the annual operating expenditure for the owner/operator**
6) **Coordinate with the fuel repatriation programs to establish the preferred time for conversion to LEU fuel. For more rapid or immediate conversions, the owner/operator may be compensated for the unused service lifetime of the repatriated HEU fuel**

ARGONNE NATIONAL LABORATORY
OPERATED BY THE UNIVERSITY OF CHICAGO

INL
Idaho National Laboratory

RERTR Program Elements

Defense Nuclear Nonproliferation

1) **The RERTR program includes three main elements:**

2) **Conversion and Analysis**

- **Feasibility Studies, Operational and Safety Analyses, Regulatory Assistance, Reactor Analysis/Code Development**
- **Collaboration with International partners**

3) **Fuel Development and Supply**

- **Enables conversion of 34 reactors**
- **Fuel Supply for Conversion**
- **Very high-density U-Mo fuel will enable additional reactors to convert**
- **Collaboration with International partners;**
  - **International Fuel Development Working Group,**
  - **Russian Fuel Development and Conversion program,**

    (U.S.-Russian Bratislava Summit)

4) **^{99}Mo Target and Process Development**

- **Addresses all processes utilized**
- **Collaboration with International partners**

Current International Activities

Defense Nuclear Nonproliferation

Country	Conv. Analysis	Fuel Dev	Mo-99
Argentina	X	X	X
Bulgaria	X		
Canada	X	X	
Czech Republic	X		
France		X	
Indonesia			X
Kazakhstan	X		
Libya	X		
Portugal	X		
Russia	X	X	
South Korea		X	X
Ukraine	X		
Uzbekistan	X		
Vietnam	X		

RERTR is also working with the IAEA on Mo-99, MNSR/Slowpokes and Fuel Qualification.

U.S. Research Reactor Conversion Status

National Nuclear Security Administration
Defense Nuclear Nonproliferation

1) **Coordinate within DOE to support U.S. universities according to individual facility requirements.**
   - Maintain support to Universities for Scientific Mission
   - Implement Conversion for nonproliferation concerns
2) **Coordination with NRC**
3) **Other U.S. Reactors intending to begin performing Conversion Analysis in 2005**
   - ATR
   - MITR
   - HFIR
4) **Milestones-University of Florida and Texas A&M are both scheduled for conversion by Summer of 2006**
   - Place orders for Fuel by May 2005
   - Submit application to NRC for conversion by July 2005
   - Obtain NRC conversion order by May 2006
   - Ship spent fuel as soon as possible after conversion

Argonne National Laboratory
Operated by The University of Chicago

INL
Idaho National Laboratory

Conversion Analysis

National Nuclear Security Administration
Defense Nuclear Nonproliferation

1) **Performs FEASIBILITY STUDIES to determine suitable LEU fuel assembly designs for each reactor**
   - Design fuel assemblies using qualified LEU fuels and fuels under development
   - Compare reactor performance with HEU and LEU fuels
   - Calculate two key safety parameters

2) **Performs the OPERATIONAL AND SAFETY ANALYSES to show**
   - Transition from HEU to LEU fuel can be done safely and without interrupting normal operations
   - LEU reactor satisfies all safety requirements

3) **Assists reactor organizations in resolving REGULATORY ISSUES**
   - Assists in formulating safety requirements (when requested)
   - Assists in answering questions posed by regulatory bodies and their experts regarding the reactor's safety documentation

ARGONNE NATIONAL LABORATORY
OPERATED BY THE UNIVERSITY OF CHICAGO

INL
Idaho National Laboratory

Fuel Development Strategy

National Nuclear Security Administration
Defense Nuclear Nonproliferation

Diverse, multi-level R&D program developed to maximize potential for successful fuel qualification

1) Pursue multiple fuel technology paths
   - Monolithic fuel (3 fabrication routes), Mg-matrix fuel, modified matrix and particles
   - Alternative fuels: Zr-based fuels, particle coating (CNEA)
2) Early testing at high power and at prototypic scale
   - RERTR-6 experiment now installed in ATR, high power RERTR-7 experiment in October 2005, RERTR-8 – very high power, short duration (mid 2006 in ATR)
   - IRIS-5 and AFIP full-size plate tests in OSIRIS and ATR begin early in 2006
3) International collaboration and information exchange
4) Planning for adequate testing opportunities in multiple reactors
   - 3 miniplate tests, 4 full-size plate tests, 3 series of element tests for fuel qualification
5) Engage fuel manufacturers to ensure commercialization of fuel
6) Russian fuel development program
   - Collaboration on development of tube and pin-type fuels with Russian institutes in Russia
   - Additional emphasis given by presidential agreement at Bratislava

ARGONNE NATIONAL LABORATORY
OPERATED BY THE UNIVERSITY OF CHICAGO

INL
Idaho National Laboratory

^{99}Mo Production with LEU

National Nuclear Security Administration
Defense Nuclear Nonproliferation

1) Development of LEU targets and chemical processing methods to enable the production of ^{99}Mo without reliance on HEU
   - Production of equivalent (or greater) ^{99}Mo yields
   - Use of same irradiation positions, handling, and transportation methods
   - Development of recovery processes that imply no decrease in yield or purity
   - Development of waste treatment and disposal options to minimize impacts of conversion

2) Annular LEU-foil target allows
   - Potential for significantly more ^{235}U per target than conventional HEU target
   - If foil production is made economical, target fabrication should be cheaper than current HEU targets
   - Alkaline digestion of LEU-foil targets uses significantly less solution than for an HEU foil
   - Acid dissolution will use the same or less solution than for an HEU target

ARGONNE NATIONAL LABORATORY
OPERATED BY THE UNIVERSITY OF CHICAGO

INL
Idaho National Laboratory

ANL Approach Addresses Common Concerns

NNSA National Nuclear Security Administration
Defense Nuclear Nonproliferation

1) About five times more LEU (~20% ^{235}U) required than HEU (~93% ^{235}U) for equal ^{99}Mo yield.

All else being *equal*:

- Targets must contain 2-5 times more uranium
- Mo recovery/purification process must deal with more uranium
- Solid waste will contain more uranium

2) Increase in total U can be overcome by:

- Use of foil targets instead of dispersion targets
- Significantly decrease amount of Al in the target to decrease the amount of liquid needed for digestion
- Improve efficiency of ^{99}Mo recovery/purification processes to minimize volume
- Address solid waste issues

ARGONNE NATIONAL LABORATORY
OPERATED BY THE UNIVERSITY OF CHICAGO

INL Idaho National Laboratory

Summary

Defense Nuclear Nonproliferation

- **U.S. RERTR program depends upon cooperation with and support from our international partners for success**
- **U.S. RERTR program is working domestically and internationally to minimize the use of HEU in civil nuclear applications**
- **A goal of the RERTR program is to enable the conversion to LEU to occur without burden to the owners and operators of facilities that are converted**
- **A goal of the RERTR program is the conversion of 105 reactors by 2014**

Announcement

Defense Nuclear Nonproliferation

RERTR-2005 CONFERENCE

New Orleans, LA, USA

November 6 – 10, 2005

Additional Information to become available soon at the RERTR Web site:

www.rertr.anl.gov